

Aim:-

To draw the V-I characteristics of a PN junction diode.

Apparatus Required :-

PN Junction Kit and Connecting wires etc.

Theory :-

If a P-type Semiconductor is automatically joined to N-type Semiconductor then P-N junction is formed.

According to current flow mechanism there are two type of biasing

- a) Forward bias
- b) Reverse bias

Forward bias :-

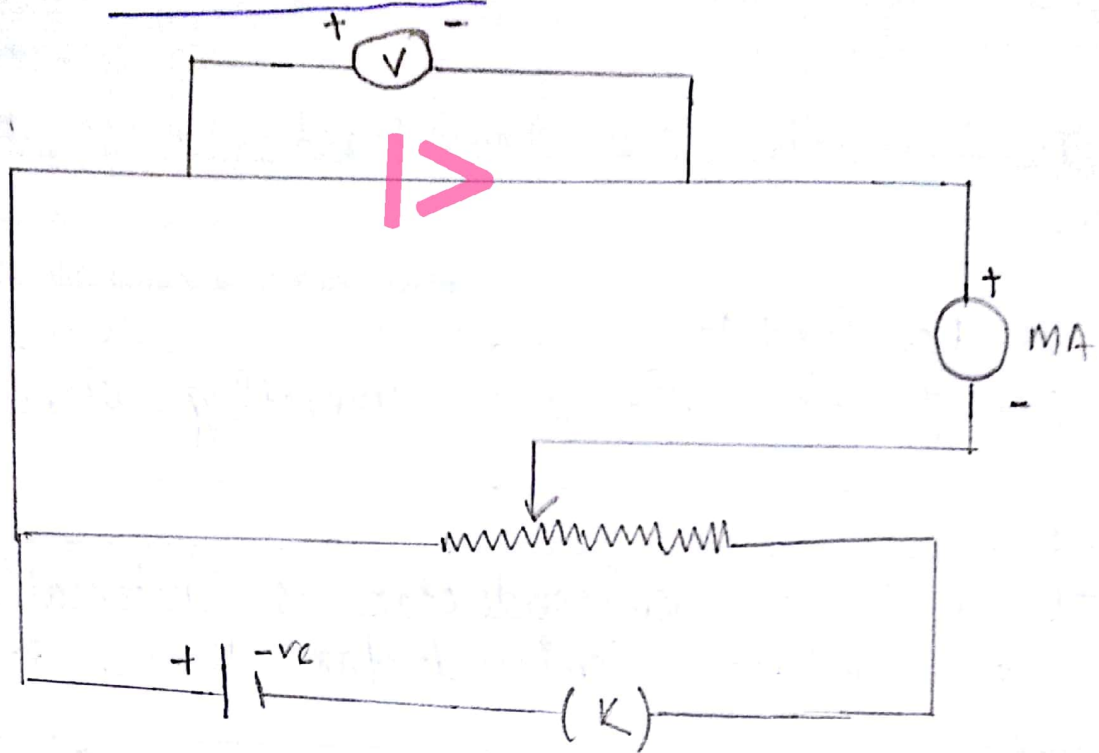
When the junction diode behaves a forward biased. Then it behaves as a low resistive device so the current increase in the circuit rapidly for small increase of bias or voltage.

Reverse bias :-

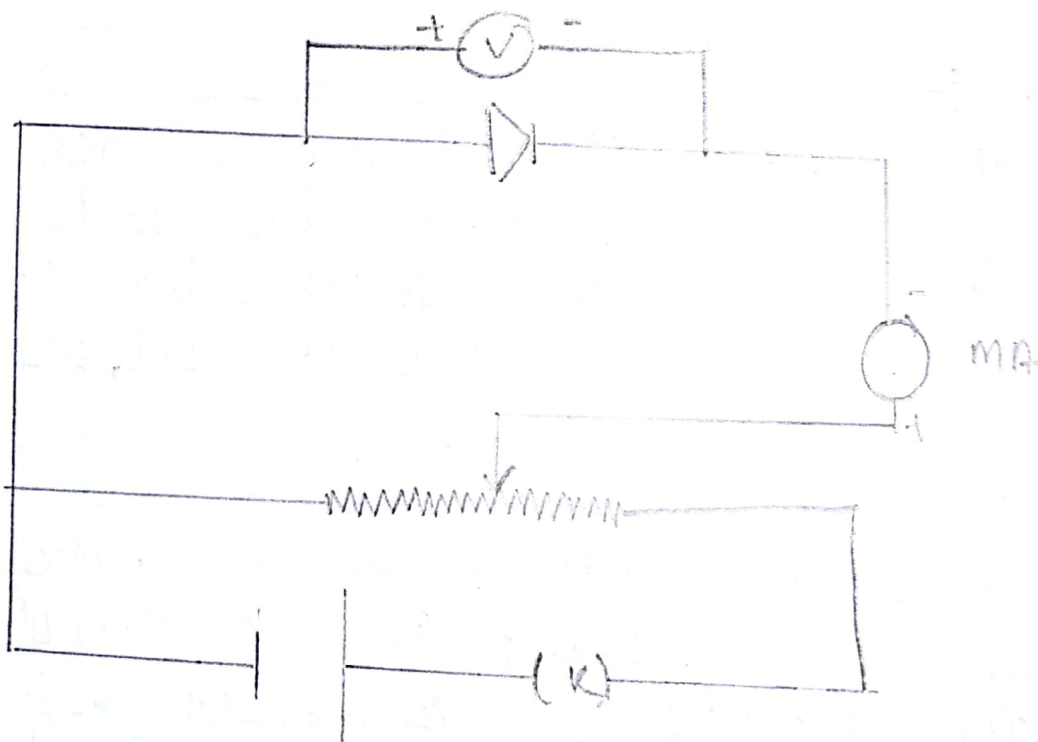
When the junction diode behaves as reverse biased initially there is no current in the circuit but there is the continuously increase of voltage in reverse biased, a small current is flowing in the circuit in the opposite direction.

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Forward bias :-



Reverse bias :-



Standardisation :- (For Voltage)

10 division = 0.5 Volt

1 division = 0.05 Volt

For Current (In forward bias)

10 division = 2 mA

1 division = 0.2 mA

For Current (In reverse bias)

10 division = 10 mA

1 division = 1 mA

Tabulation-1 (Forward bias)

Volt meter Reading divisions	V_{in} (Volt)	Ammeter reading divisions	I (mA)
1	0.05	0	0
2	0.10	1	0.2
3	0.15	1	0.2
4	0.20	2	0.4
5	0.25	3	0.6
6	0.30	7	1.4
7	0.35	8	1.6
8	0.40	11	2.2
9	0.45	16	3.2
10	0.50	18	3.6

V-I Characteristic

1st quadrant - Forward Bias

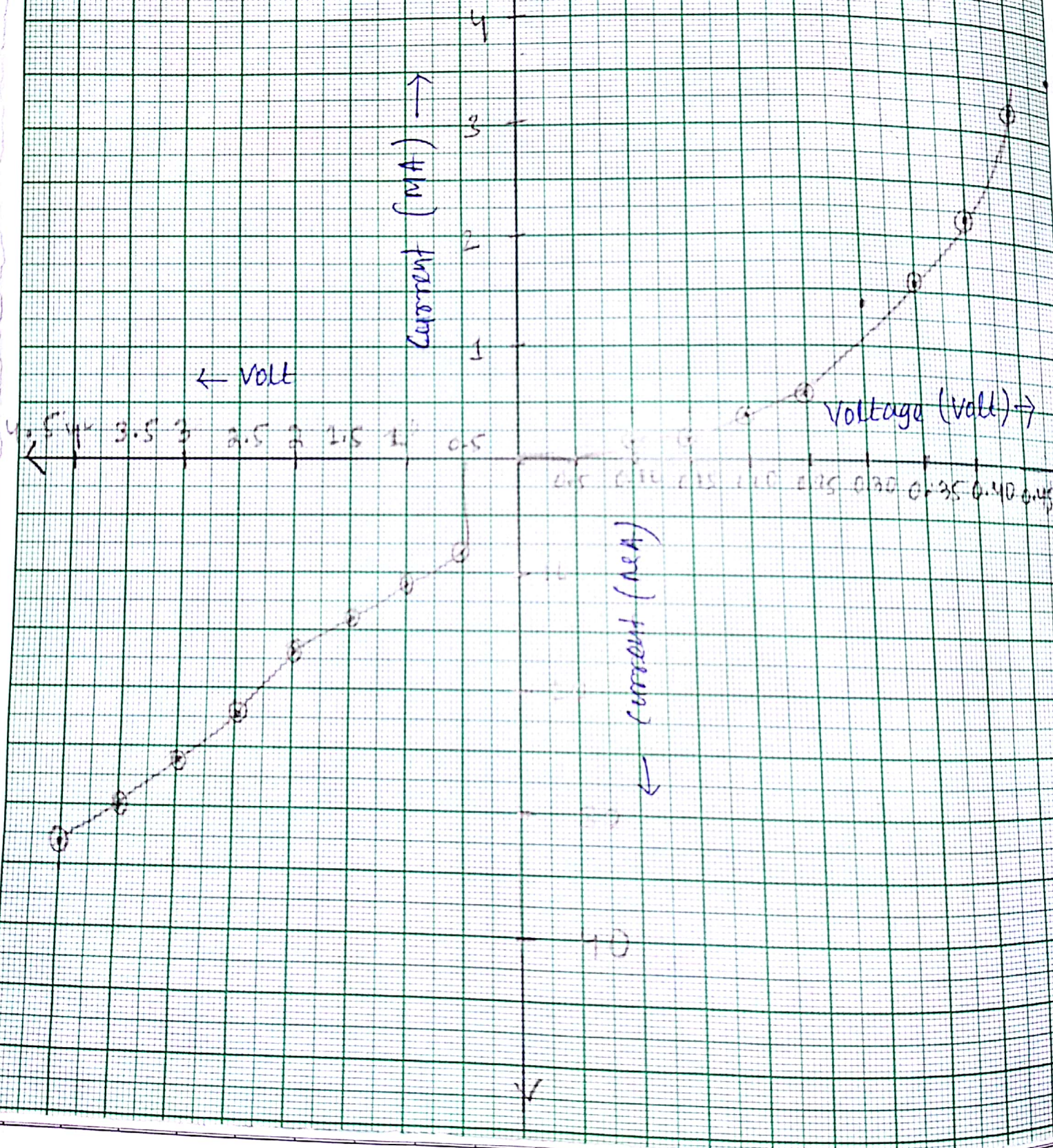
2nd quadrant - Reverse Bias

20 div = 1 mA (Y axis)

10 div = 0.50 volt (X axis)

20 div = 10 mA (Y axis)

10 div = 0.50 volt (X axis)



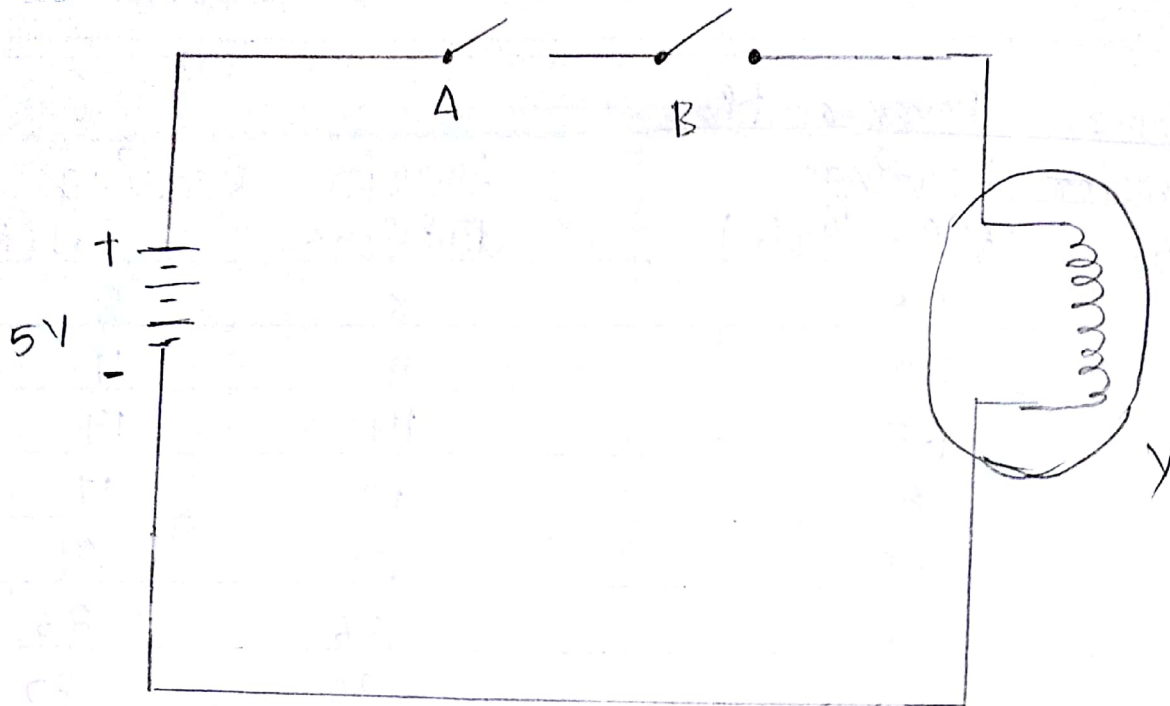
Tabulation-2 Reverse bias

Volt meter divisions	Reading V_{in} (volt)	Ammeter divisions	Reading I_{in} (mA)
1	0.5	8	8
2	1.0	11	11
3	1.5	14	14
4	2	17	17
5	2.5	21	21
6	3.0	26	26
7	3.5	30	30
8	4	33	33
9	4.5	38	38
10	5	43	43

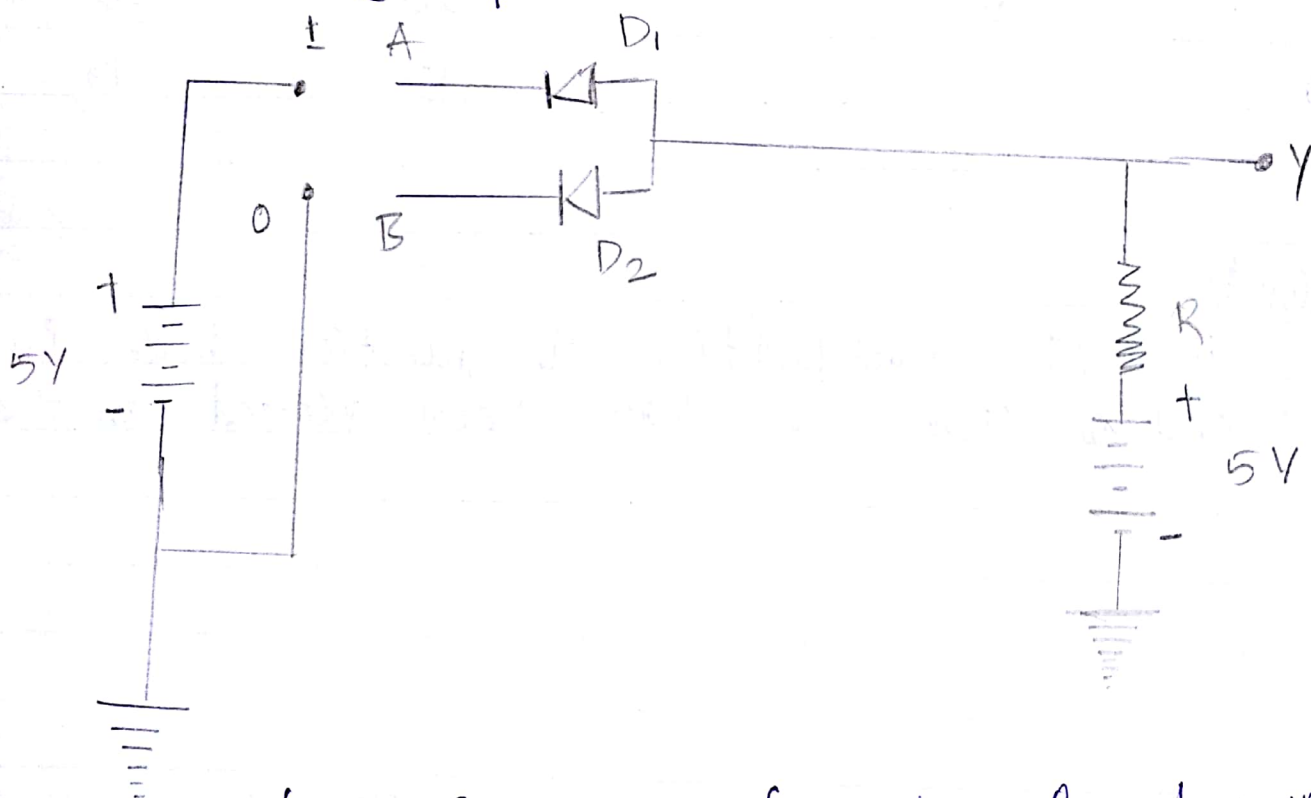
Conclusion :-

The V-I characteristics of junction diode in forward and reverse bias has been plotted on the graf.

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(Electrical circuit for AND operation)



(Circuit diagram for two input AND gate using Junction Diode)

Aim of the experiment:-

To determine or Verify the truth table of AND gate.

Theory:- (Operation of AND Gate)

There are four input possibilities during the operation of AND gate.

If both the inputs A and B are connected to the ground then both the diodes D_1 and D_2 are forward biased and they conduct current hence the voltage drop across the resistance R will be passed to the ground and output y is at zero voltage.

- If A is connected to the ground and B is connected to the +ve terminal of 5V battery, D_1 is forward bias and D_2 is reverse biased. Hence D_1 conduct current but D_2 does not conduct current. Therefore the voltage drop across the resistance R will be passed to the ground and the output 'y' is at zero voltage.

- If A is connected to the +ve terminal of 5V battery and B is connected to the ground then D_1 is reverse biased and D_2 is forward bias. Then D_1 does not conduct but D_2 can conduct current. Therefore the voltage drop across the resistance R will be passed to the ground. The output is at zero voltage.

If both the inputs A and B are connected to the +ve terminal of the 5V battery then both diodes are reverse bias and they do not

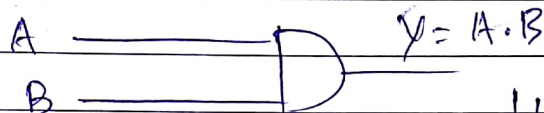
Teacher's Signature : _____

Conduct Current, hence the output is at +5Volt

Truth table

A	B	$Y = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1

Logic gate :-



(Logic symbol for AND gate)

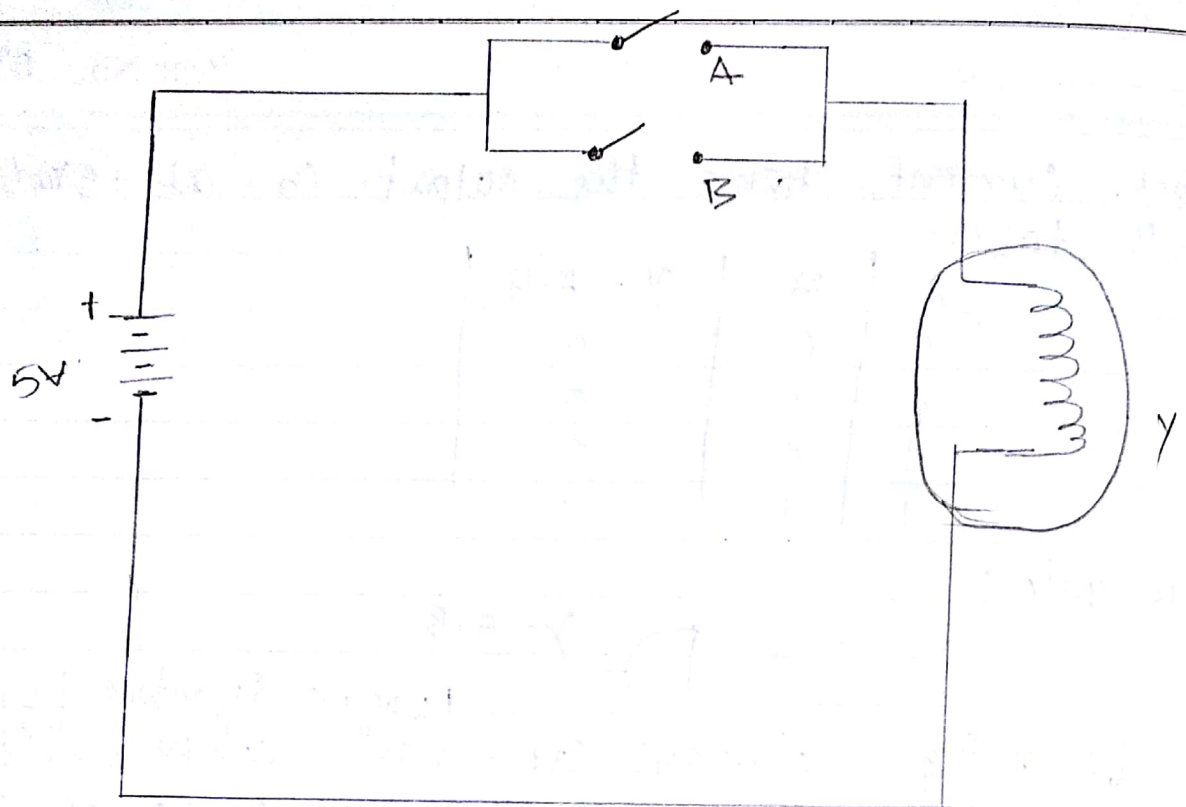
The following boolean expression can be written as

$0 \cdot 0 = 0$	$\rightarrow$	0 ANDed with 0 equal 0
$0 \cdot 1 = 0$	$\rightarrow$	0 ANDed with 1 equal 0
$1 \cdot 0 = 0$	$\rightarrow$	1 ANDed with 0 equal 0
$1 \cdot 1 = 1$	$\rightarrow$	1 ANDed with 1 equal 1

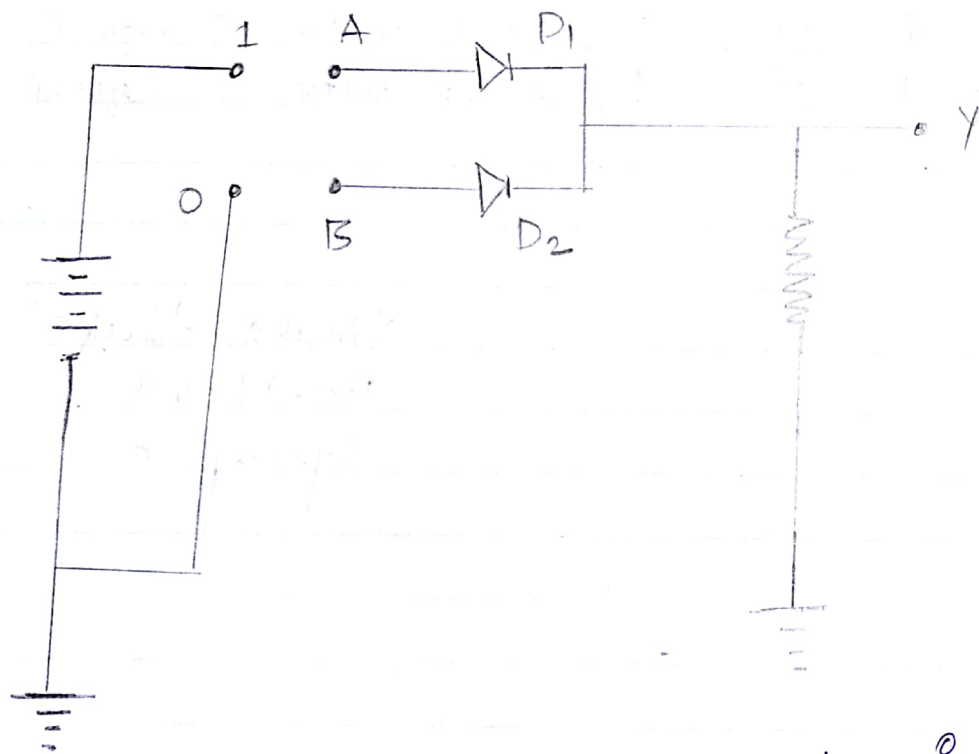
Farhana Hussain

B5-17-025

Group - A



Electrical Circuit for AND operation



Circuit diagram for two input OR gate junction diode.

Aim:- To Verify the truth table of OR Gate.

Theory:- (Operation of OR gate):-

There are 4 possibilities during the operation of OR gate.

If both the input A and B are connected to the ground then both diodes D_1 and D_2 are reverse biased and they do not conduct current. Hence the output 'y' is zero.

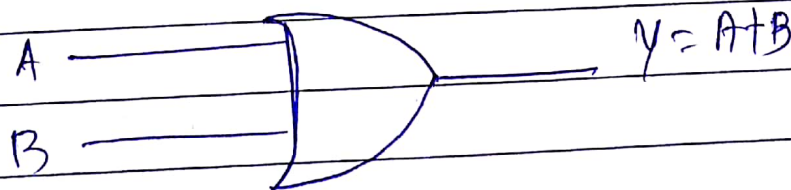
If A is connected to the ground and B is connected to the +ve terminal of 5V battery then D_1 is reverse biased and D_2 is forward biased. Hence D_1 does not conduct current but D_2 conducts current. Therefore the output y is at +5V.

If both the input A and B are connected to the +ve terminal of the battery then both diodes D_1 and D_2 are forward biased and they conduct current. Hence the output 'y' is at +5V.

Truth table:-

A	B	$y = A+B$
0	0	0
0	1	1
1	0	1
1	1	1

Logic gate



The following boolean expression can be written from the following truth table.

$$0+0 = 0 \rightarrow 0$$

$$0+1 = 1 \rightarrow 1$$

$$1+0 = 1 \rightarrow 1$$

$$1+1 = 1 \rightarrow 1$$

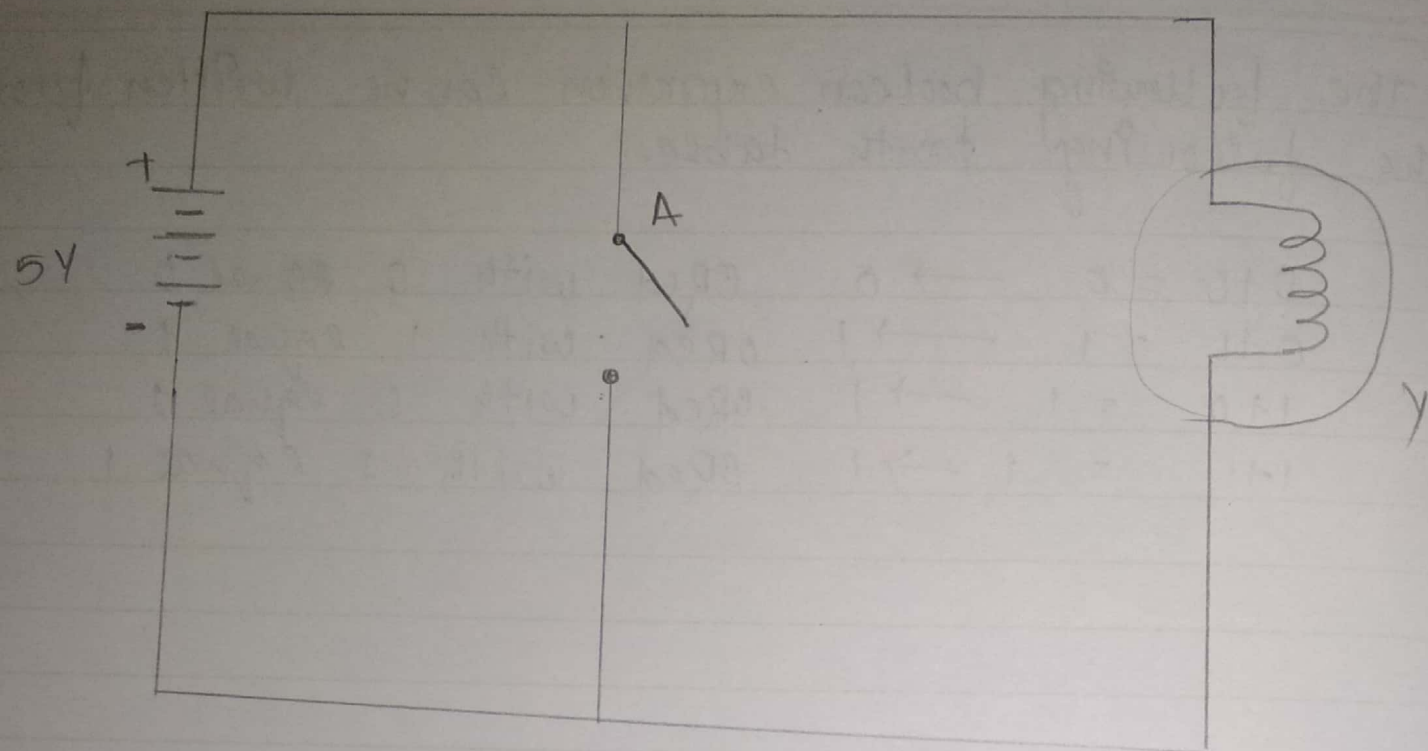
ORed with 0 equal 0

ORed with 1 equal 1

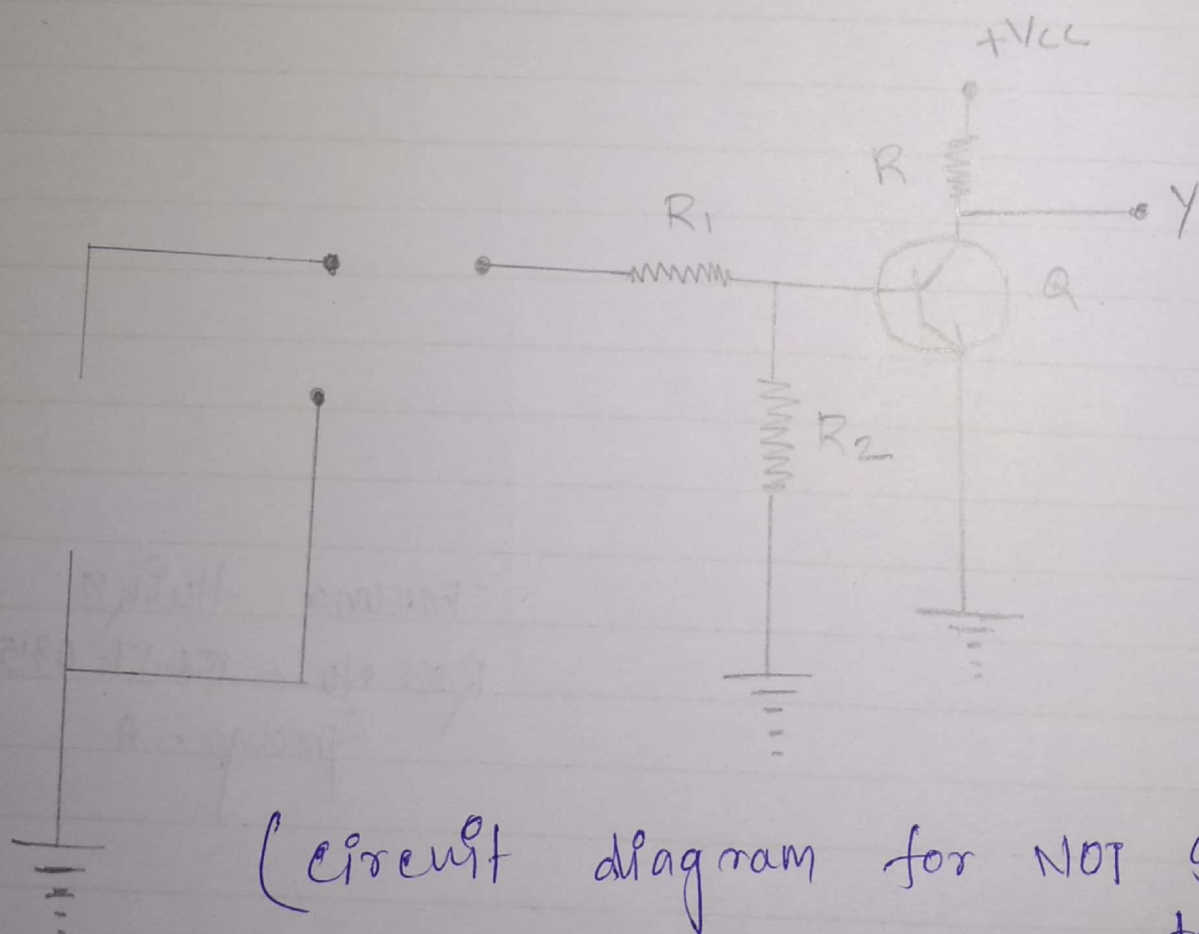
ORed with 0 equal 1

ORed with 1 equal 1

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Electrical circuit for NOT operation



(circuit diagram for NOT gate using transistor)

Aim :- To determine the truth table of NOT gate.
operation of NOT Gate :-

There are two input possibilities during the operation of NOT gate.

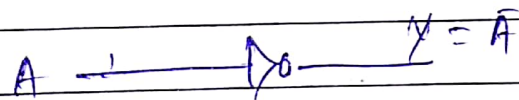
If A is connected to ground then the base of the transistor is at zero potential and transistor becomes cutoff and the collector current is zero hence the output 'Y' is at $+V_{cc}$.

If A is connected to the +ve terminal of the battery then base of transistor is at +ve potential and the transistor conducts heavily. Hence the output is at zero voltage.

Truth table :-

A	$Y = \bar{A}$
0	1
1	0

Logic gate



The following boolean expression can be written from truth table

$$\bar{0} = 1$$

$$\bar{1} = 0$$

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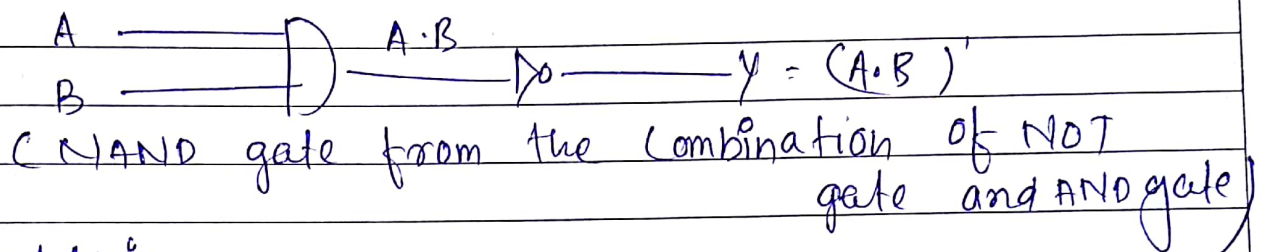
Roll No - BS-17-035

Group-A

Aim :- To Verify or determine the truth table and logic circuit of NAND gate.

Theory :-

NAND gate is combination of NOT gate and AND gate. The output of AND gate is connected to the input of NOT gate as shown in the figure.

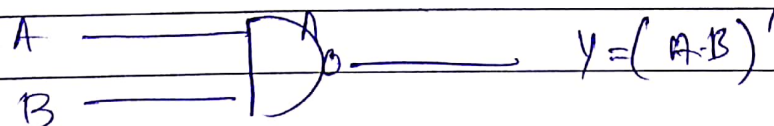


Truth table :-

A	B	$A \cdot B$	$Y = (A \cdot B)'$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

The output of a NAND gate is in state '0' only when all the inputs are in high state '1'.

Logic gate :-



The following boolean equation can be written from truth table

$$(0.0)' = 1$$

$$(0.1)' = 1$$

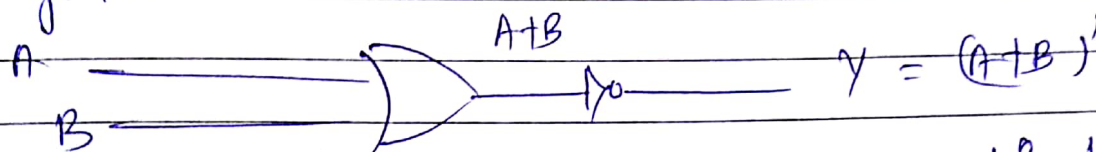
$$(1.0)' = 1$$

$$(1.1)' = 0$$

Aim :- To determine the truth table and logic circuit of NOR gate.

Theory :-

NOR Gate is combination of NOT and OR gate. The output of OR gate is connected to the input of NOT gate.



(NOR gate from the combination of NOT Gate and OR gate)

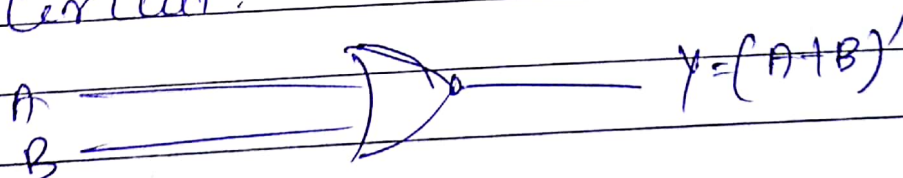
Truth table :-

A	B	A+B	$Y = (A+B)'$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

The output of NOR gate is in state 1 only when all the inputs are in state 0.

Logic

circuit :-



The following boolean expression can be written from the truth table.

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$$(0+0)' = 1$$

$$(0+1)' = 0$$

$$(1+0)' = 0$$

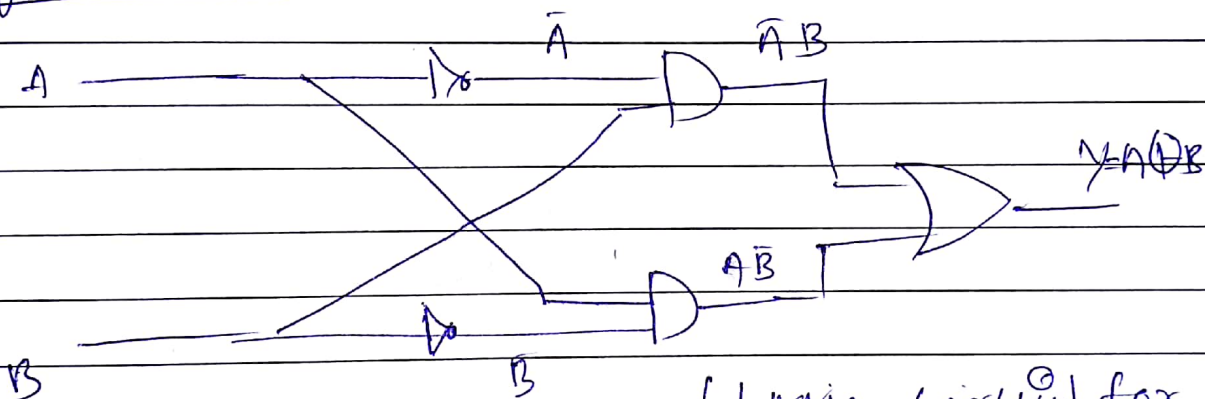
$$(1+1)' = 0$$

Aim :- To verify the truth table of XOR gate

Theory :-

XOR is short form of exclusive OR. It has two inputs. It produces the output 'high' when the inputs have odd numbers of 1's. In other words, the output is high if any but not all input are high. That is why XOR gate serves as an inequality detector. If we compare the truth table of XOR gate with that of an OR gate. The exclusive feature eliminates the similarity to the OR gate. In OR gate $y=1$ for $A=B=1$ it is exclusive nature of OR gate

Logic Circuit



(Logic circuit for XOR gate)

The boolean expression for output of XOR logic circuit is given by

$$Y = A \oplus B = \bar{A}B + A\bar{B}$$

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Truth table:-

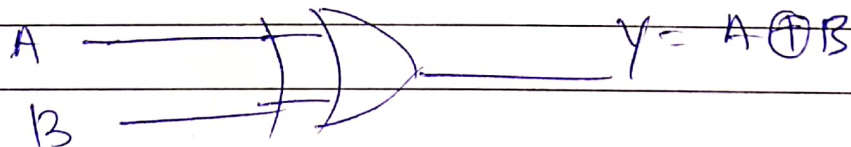
Inputs		Outputs	
A	B	OR	XOR
0	0	0	0
0	1	1	1
1	0	1	1
1	1	1	0

Logic operation

A	B	$\bar{A}$	$\bar{B}$	$\bar{A}B$	$A\bar{B}$	$Y = \bar{A}B + A\bar{B}$
0	0	1	1	0	0	0
0	1	1	0	1	0	1
1	0	0	1	0	1	1
1	1	0	0	0	0	0

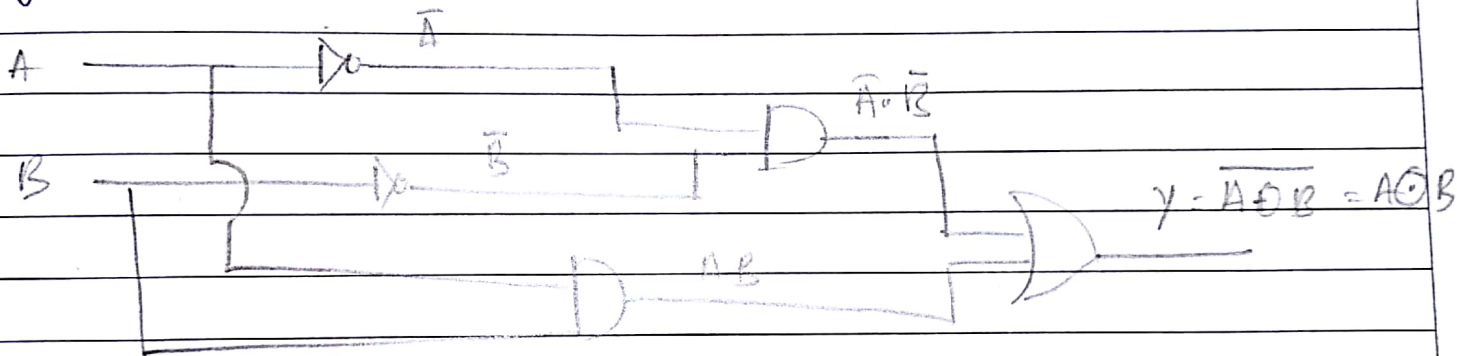
Observation:-

Output from XOR gate is 1 when the two inputs are at different state with respect to each other.

Logic Symbol

Aim:- To verify the truth table of X-NOR gate
Theory:-

X-NOR is a short form of exclusive NOR. It has two inputs, XNOR gate is complement to XOR gate. It produces the output high when the inputs have even number of 1's or 0's. In otherhand, the output is high if all the input either high or low i.e both are equal. That is why XOR gate serves as coincidence.
Logic Circuit:-



The boolean expression for output of XNOR Logic Circuit given as

$$Y = A \odot B = \overline{A \oplus B} = AB + \bar{A}\bar{B}$$

Input		Output			
A	B	OR	XOR	NOR	XNOR
0	0	0	0	1	1
0	1	1	1	0	0
1	0	1	1	0	0
1	1	1	0	1	1

Logic Operation:-

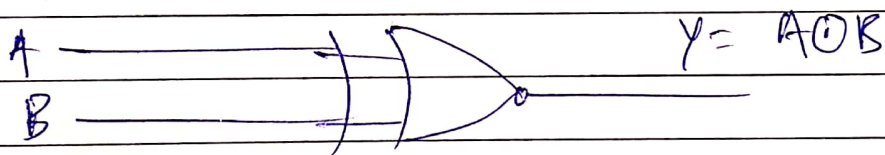
A	B	$\bar{A}$	$\bar{B}$	$A \cdot B$	$\bar{A} \cdot \bar{B}$	$Y = A \cdot B + \bar{A} \cdot \bar{B}$
0	0	1	1	0	1	1
0	1	1	0	0	0	0
1	0	0	1	0	0	0
1	1	0	0	1	0	1

Observation:-

Output of X-NOR gate is in state '1' only when its two input are same state with respect to each other.

Logic Symbol:-

The logic symbol for a two 'input' X-NOR gate depends on A and B and given as



Aim :- To measure Voltage & time period of a periodic wave using CRO

Theory :-

Cathode ray oscilloscope is one of the useful electrostatic equipment, which gives a visual representation of electrical quantities such as Voltage and Current waveform in an electrical circuit. The frequency and peak voltage of an alternating current can be determined by CRO. On the screen of CRO, the horizontal axis represents time and vertical axis represents potential and voltage. The time knob and voltage knob are adjusted to get a full visual waveform of A.C. on the screen of CRO.

Time period of A.C. $T = (\text{No of units in the time axis}) \times (\text{length of the time base})$

∴ frequency of the A.C. $f = \frac{1}{T}$

peak Voltage of A.C. = V_0
 $2V_0 = (\text{no of units in the voltage axis}) \times (\text{Range of voltage knob})$

Procedure :-

- (1) To measure the A.C. voltage by sinusoidal wave form, the A.C. signal from the signal generator is applied across the y-plates.

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- (ii) The voltage (deflection) sensitivity bandwidth (y-plates) & time base bandwidth switch (x-plates) are adjusted such that steady picture of the waveform is obtained on the screen.
- (iii) The vertical height i.e. peak to peak height is measured. When this peak to peak height is multiplied by the voltage (deflection) sensitivity i.e. volt/div, we get the peak to peak voltage ($2V_0$).
- (iv) From this we get the peak voltage (V_0).
- (v) An unknown frequency source (signal generator) is connected to CRO, time base signal is connected to x-plates (internally connected).
- (vi) The horizontal length between the successive peaks of sinusoidal wave on the screen is noted.
- (vii) When this horizontal length is noted multiplied by time base i.e. ms/div, we get the time period (T) in ms. It is converted to second.
- (viii) The horizontal reciprocal of the time period ($1/T$) gives the frequency (f) in Hz.

Calculation:-

No of units in the time axis - 5.6 unit

Range of the time knob - 0.3 ms/div

$$\text{So } 2T = (5.6 \times 0.3) \text{ ms}$$

Expt. No.

Time period of A.C $T = \left(\frac{5.6 \times 0.3}{2} \right) \text{ ms}$
 $T = 0.84 \text{ ms} = 0.84 \times 10^{-3} \text{ sec}$

frequency of the A.C

$$f = \frac{1}{T} = \frac{1}{0.84} \times 10^3 \text{ Hz}$$

$$\Rightarrow f = 1190.47 \text{ Hz}$$

No of units in Voltage axis = 4.2 unit

Range of the Voltage knob = 2 mV/div

So Voltage $2V_0 = (4.2 \times 2) \text{ mV}$

$$V_0 = 4.2 \text{ mV}$$

$$V_0 = 4.2 \times 10^{-3} \text{ V}$$

$$V_0 = 0.0042 \text{ V}$$

Conclusion:-

from the above experiment the value of frequency & peak voltage of oscillation are found to be 1190.47 Hz and 0.042 V respectively.

Aim :-

To show the characteristic curve of zener diode.

Theory :-

Semiconductor PN-Junction diode are generally used as rectifier, they are suitable for converting AC into DC but they suffer from the disadvantage that their maximum shape, inverse voltage & relatively small. When average voltage is applied conducting stop and the PN Junction diode blocks the reverse current like any other rectifier, as the reverse voltage increases a small current flows in the circuit, if however the reverse potential is increased beyond a limit the reverse current increases sharply to a higher value. At the voltage where the current increase suddenly is called break down voltage. This sudden increase in current is known as ZENER CURRENT. The zener current diode makes a virtue of it and apparatus at this very points.

Procedure :-

Forward characteristics :-

1. Make all the connecting as shown in Fig.(a)
2. knob of potentiometer 'R' is kept fully anti-clockwise.
3. Now switch on the unit and set the voltage to 0V.
4. Increase the voltage in small steps, and note down the corresponding current. Note down the observation table.

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5. Plot a graph between voltage and current.

Reverse bias characteristics:-

1. Make all the connections as fig (b).
2. Knob of the potentiometer R is kept fully anticlockwise.
3. Now switch on the unit and set the voltage to '0' V.
4. Increase the voltage in small steps and note down the corresponding current. Note down the observation table.

5. Plot a graph between voltage and current.

Standardisation:-

In forward bias,

For ammeter, 10 division = 2 mA

1 division = 0.2 mA

For voltmeter, 10 division = 0.25 V

1 div. = 0.025 V

or reverse bias,

For ammeter, 10 division = 20 μ A

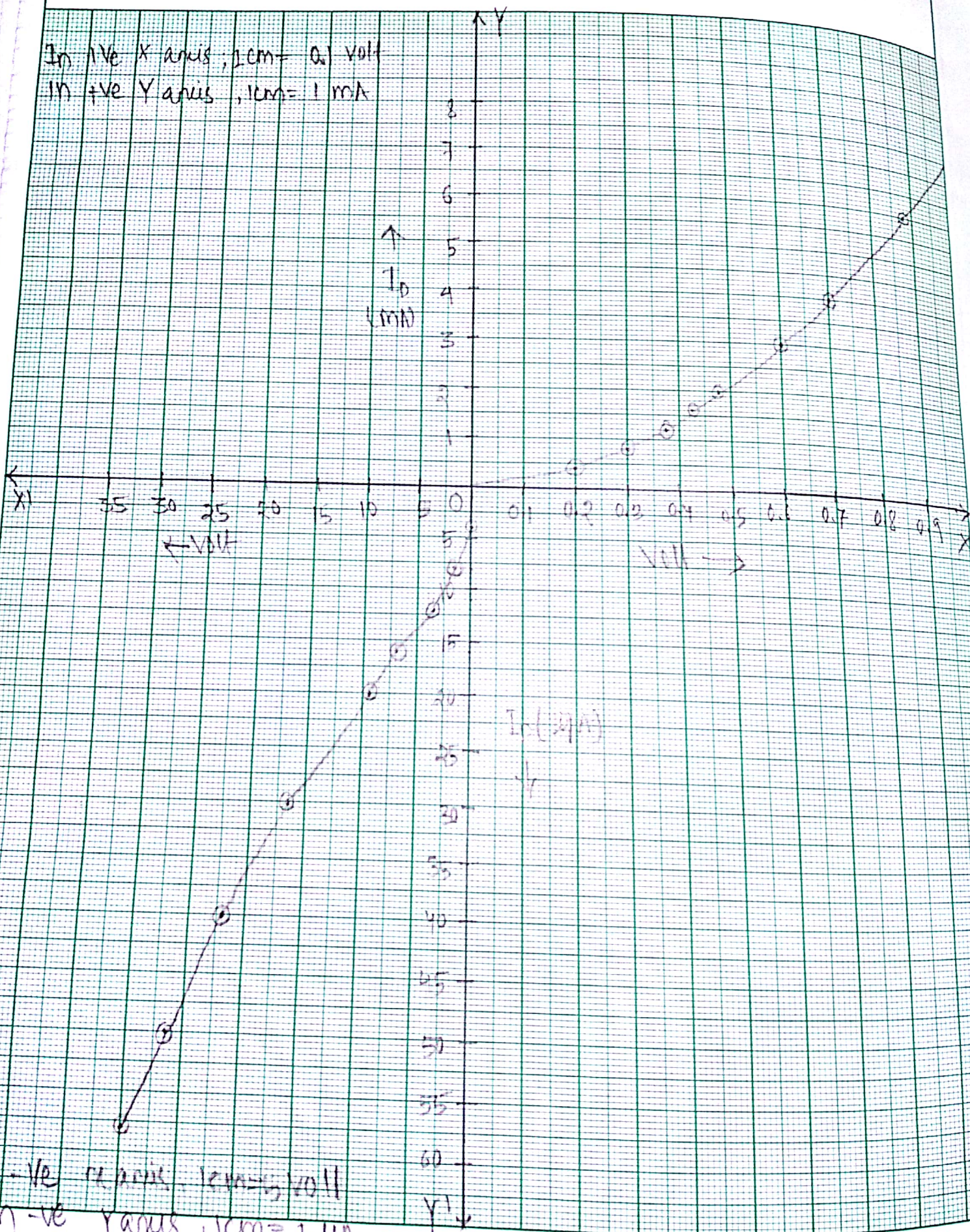
1 division = 2 μ A

For voltmeter, 10 division = 5 Volt

1 division = 0.5 Volt

In +ve X axis; 1cm = 0.1 Volt

In +ve Y axis; 1cm = 1 mA



TabulationForward biased

No. of Obs	V_D (m volts)	I_D in mA
1	2	0.20
2	12	0.30
3	15	0.375
4	17	0.425
5	19	0.475
6	24	0.600
7	28	0.700
8	35	0.875
9	42	1.050

Reverse Biased

No. of Obs	V_D in volts	I_D in μA
1	0	2
2	3	4
3	7	8
4	14	12
5	19	16
6	33	20
7	44	25
8	53	30
9	60	35

Conclusion:-

From the above experiment we have the $V-I$ characteristic of Zener diode is drawn in both forward biased and reverse region.

*11.9. SOME OTHER TYPES OF JUNCTION DIODES

1. Zener Diode

The characteristics of a junction diode [Fig. 11.11 (b)] indicate that when reverse biased are given a proper high voltage a breakdown occurs and a current flows in negative direction. The voltage at which this happens is called "Zener breakdown voltage". The mechanism of breakdown can be to one of the following two ways.

(i) **Zener breakdown.** The potential difference across the reverse biased junction diode may be just sufficient to tear off the electron away from the atom, thus creating an electron-hole pair. This results in an increase in the number of minority charge carriers which in turn results in an increase in current due to a variation in potential difference. This process is a reversible process. On decreasing the potential difference, the current falls back to smaller value.

(ii) **Avalanche breakdown.** When the potential difference of the reverse biased junction diode is very high, the electric field is high enough to provide sufficient kinetic energy to a charge carrier which enables it to cause ionisation due to collision against an immobile atom. The new pair of electron-hole, thus created, also gets accelerated and becomes capable of producing ionisation. This multiplication takes place and soon an *avalanche* of charge carriers is produced causing a flow of large current in the opposite direction.

When a junction diode operates beyond Zener voltage, the characteristics indicate that the curve is nearly parallel to I-axis. This means whatever may be the current through the diode, the potential difference across it remains constant. This means a zener diode can be made to act as a source of constant voltage. The symbolic representation of a zener diode is shown in Fig. 11.11 (i) while the circuit diagram indicating that it acts as a source of constant voltage is shown in Fig. 11.11 (ii).

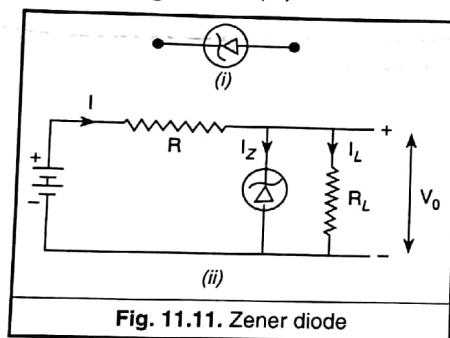


Fig. 11.11. Zener diode

Since Zener diode and the load resistance R_L are connected in parallel with each other, potential difference across them is same. Let it be ' V_0 '. The main current I is divided in diode and load, therefore,

$$I = I_Z + I_L \quad \dots (5)$$

Voltage equation of the first mesh can be written as

$$V_0 = V - IR \quad \dots (6)$$

Also $V = I_L R_L \quad \dots (7)$

Case (i) V remaining constant and R_L changing

Since V is a constant quantity, $\delta V = 0$

Since V_0 is also a constant quantity, $\delta V_0 = 0$

Differentiating equation (6), $\delta V_0 = \delta V - R \delta I$

Substituting for δV_0 and δV in equation (6), we get $0 = 0 - R \delta I$

where δI is the variation in net current due to a variation in R_L .

$$\therefore \delta I = 0$$

From equation (5), we get $\delta I = \delta I_Z + \delta I_L$

Substituting $\delta I = 0$

$$\delta I_Z + \delta I_L = 0$$

$$\delta I_Z = -\delta I_L$$

If load resistance R_L is changed without changing V , the current flowing through zener diode and that through R_L adjust themselves in such a way that the net current in the circuit remains unaffected.

Case (ii) Changing V keeping R_L fixed

Since $\delta V_0 = 0$ always, using equations (6) and (7), we get

$$0 = \delta V - R \delta I \quad \text{or} \quad \delta V = R \delta I$$

$$0 = R_L \delta I_L \quad (R_L = \text{constant})$$

From equation (5), we get $\delta I = \delta I_L + \delta I_Z$

Putting $\delta I = 0$, we get $\delta I = \delta I_Z$

Thus, if the supply voltage is changed keeping load resistance constant, the change in current through zener diode is same as the change in total current, keeping current through the load resistance constant.

Zener dynamic resistance (r_Z)

d.c. resistance of a zener diode is defined as the inverse of the slope of junction diode characteristic.

$$r_Z = \frac{\delta V_0}{\delta I_Z}$$

Here $\delta V_0 = 0$, $r_Z = 0$

Practically r_Z has a finite but very small value. Since V_0 is constant while I_Z may vary, r_Z is not a constant quantity.

2. Photo Diode

It consists of a reverse biased junction diode below the breakdown voltage. A beam of light is made to fall on the junction. Energy from photon tears the electron away from the atom thus producing additional electron-hole pair. This produces an electric current thus causing the diode to conduct. Fig. 11.12 (i) and (ii) give the symbolic representation and working of photo diode.

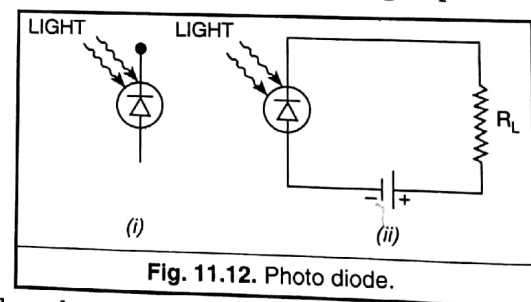


Fig. 11.12. Photo diode.

It has been found that the current through the circuit increases almost linearly with the increase in the flux of light. This type of diode has found extensive use in light operated switches and reading of computers, punched cards, etc.

3. Light Emitting Diode (LED)

We know that some energy is required to pull the electron away from the atom. Thus, reaction of electron-hole pair is an energy absorbing process. Conversely